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Improving CP Measurement with Muon Decay At Rest

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We explore the possibility of using the recently proposed THEIA detector to measure the $\bar{\nu}_\mu \to \bar{\nu}_e$ oscillation with neutrinos from a muon decay at rest (μDAR) source to improve the leptonic CP phase measurement. Due to its intrinsic low-energy beam, this μTHEIA configuration (μDAR neutrinos at THEIA) is only sensitive to the genuine leptonic CP phase δ_D and not contaminated by the matter effect. With detailed study of neutrino energy reconstruction and backgrounds at the THEIA detector, we find that the combination with the high-energy DUNE can significantly reduce the CP uncertainty, especially around the maximal CP violation cases $\delta_D = \pm 90^\circ$. Both the μTHEIA-25 with 17 kt and μTHEIA-100 with 70 kt fiducial volumes are considered. For DUNE + μTHEIA-100, the CP uncertainty can be better than 8°.

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